Studentship Code: ECS3
Studentship Project Title: Design and Implementation of a Generalized Topology of Narrowband and Wideband Bandpass Modulator for IF and RF applications

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Background to research and synopsis
The widespread use of mixed-signal based systems in conjunction with the numerous benefits provided by digital techniques have significantly increased the need for high-resolution Analog-to-Digital (A/D) and Digital-to-Analog (D/A) converters and systems. Sigma-delta modulation (SDM) is a technique that may be employed to perform high-resolution A/D conversion for low-to-medium signal bandwidth applications. It utilizes oversampling and noise-shaping to trade-off operation speed for amplitude resolution. Bandpass A/D converters are well suited in digital radio systems, receivers for digital mobile cellular telephony, satellite communication services, in phased-array ultrasound imaging and GNSS front-end applications.

Objectives
The first objective involves applying techniques in non-linear control theory such as Describing Functions (DF) in order to derive more accurate mathematical models for single- and multi-bit quantizers in single- and multi-stage modulators. It is intended that the derived mathematical models for the gains of the quantizers can be used to predict modulator stability and tonality more accurately saving considerable simulation time. The work in this area will investigate an alternative approach to predicting stability through the use of synthetic signals that are custom designed to exhibit given statistical properties, which will be compared to those obtained from the DF method.

The second objective involves devising a more robust technique for the design of stable single-bit and multi-bit single-stage modulators for multi-tone inputs. This technique may be further extended to incorporate an adaptive dithering scheme to yield additional improvements to resolution and modulator stability, as well as introducing and incorporating the concept of adaptive OSRs based on input signal dynamics.

The third objective involves developing a system-level methodology that will include working out a practical sequence of steps that a designer needs to follow in order to design narrowband and wideband modulators for a given set of specifications in terms of the required SNR, DR, bandwidth, centre frequency as well as an acceptable level of tonality in the output spectrum. The concept of adaptive OSRs will be deployed and evaluated against their fixed OSR counterparts.

The fourth objective involves the design of a generalized bandpass modulator topology that can utilize the above developed methodology to accomplish narrowband and wideband noise-shaping with variable OSRs for IF and RF applications. This implemented topology can be then used to speed up the evaluation of bandpass modulators at the system-level.

The fifth objective involves prototyping and realizing this generalized topology for proof of concept in Field Programmable Analog Arrays (FPAA) using the AnadigmDesigner2 EDA software and prototyping system for real-time real signal test and validation.

Bibliography

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